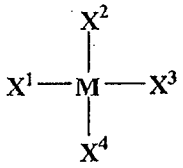
CLAIMS

1. A catalyst composition comprising a contact product of a hybrid metallocene compound and an activator,

wherein the hybrid metallocene compound has the formula:



(I);

wherein:

M is Zr, Hf, or Ti;

X^1 and X^2 independently are a halide or a substituted or unsubstituted aliphatic, aromatic, or cyclic group, or a combination thereof;

X^3 is a substituted or unsubstituted cyclopentadienyl, indenyl, or fluorenyl group, any substituents on X^3 independently are a hydrogen atom or a substituted or unsubstituted aliphatic, aromatic, or cyclic group, or a combination thereof;

X^4 is $-O-R^A$, $-NH-R^A$, $-PH-R^A$, $-S-R^A$, or $-CR^B=NR^C$,

wherein:

R^A is an aryl group substituted with an alkenyl substituent, any substituents on R^A other than the alkenyl substituent independently are a hydrogen atom or a substituted or unsubstituted alkyl, alkenyl, or alkoxy group; and

R^B and R^C independently are a hydrogen atom or a substituted or unsubstituted aliphatic, aromatic, or cyclic group, or a combination thereof.

2. The catalyst composition of claim 1, wherein X^1 and X^2 independently are a methyl group, a phenyl group, a benzyl group, or a halide.

3. The catalyst composition of claim 1, wherein each substituent on X^3 independently is a hydrogen atom, a methyl group, an ethyl group, a propyl group, an n-butyl group, a t-butyl group, or a hexyl group.

4. The catalyst composition of claim 1, wherein the alkenyl substituent on R^A is an ethenyl, a propenyl, or a butenyl.

5. The catalyst composition of claim 1, wherein each substituent on R^A other than the alkenyl substituent independently is a hydrogen atom, a methyl group, an ethyl group, a propyl group, an n-butyl group, a t-butyl group, a methoxy group, an ethoxy group, a propoxy group, or a butoxy group.

6. The catalyst composition of claim 1, wherein X^4 is -O-R^A.

7. The catalyst composition of claim 1, wherein R^B and R^C independently are a hydrogen atom, a methyl group, an ethyl group, a propyl group, an n-butyl group, a t-butyl group, a phenyl group, a benzyl group, a tolyl group, or a xylyl group

8. The catalyst composition of claim 1, wherein the activator is an activator-support comprising a solid oxide treated with an electron-withdrawing anion, wherein:

the solid oxide is silica, alumina, silica-alumina, aluminum phosphate, heteropolytungstates, titania, zirconia, magnesia, boria, zinc oxide, any mixed oxides thereof, or any mixture thereof; and

the electron-withdrawing anion is fluoride, chloride, bromide, phosphate, triflate, bisulfate, sulfate, or any combination thereof.

9. The catalyst composition of claim 8, wherein the activator-support further comprises a metal or metal ion, and wherein the metal or metal ion is zinc, nickel, vanadium, silver, copper, gallium, tin, tungsten, molybdenum, or any combination thereof.

10. The catalyst composition of claim 1, wherein the activator is an activator-support comprising a clay mineral, a pillared clay, an exfoliated clay, an exfoliated clay gelled into another oxide matrix, a layered silicate mineral, a non-layered silicate

mineral, a layered aluminosilicate mineral, a non-layered aluminosilicate mineral, or any combination thereof.

11. The catalyst composition of claim 1, further comprising an organoaluminum compound having the formula:

$$Al(X^5)_m(X^6)_{3-m};$$

wherein:

X^5 is a hydrocarbyl;

X^6 is an alkoxide or an aryloxide, a halide, or a hydride; and

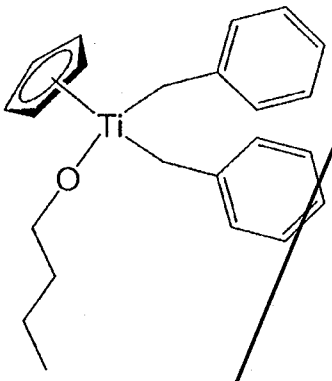
m is from 1 to 3, inclusive.

12. The catalyst composition of claim 11, wherein the organoaluminum compound is trimethylaluminum, triethylaluminum, tri-n-propylaluminum, diethylaluminum ethoxide, tri-n-butylaluminum, diisobutylaluminum hydride, triisobutylaluminum, diethylaluminum chloride, or any combination thereof.

13. The catalyst composition of claim 1, wherein the activator is an activator-support, an aluminoxane compound, an organoboron or organoborate compound, an ionizing ionic compound, or any combination thereof.

14. A catalyst composition of any of claims 1 - 13,

wherein the hybrid metallocene compound is:



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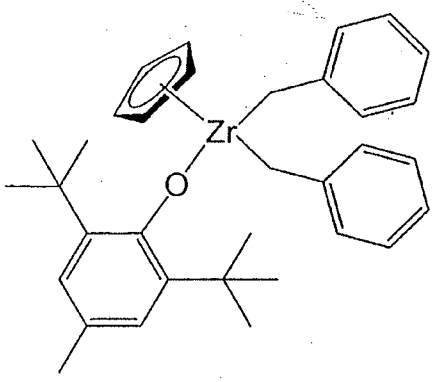
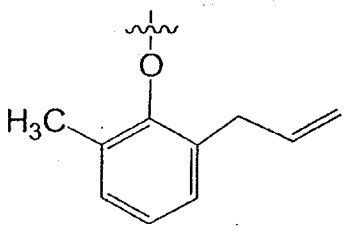


; or

Indenyl(X^4)Zr(CH_2Phenyl)$_2$; wherein X^4 is



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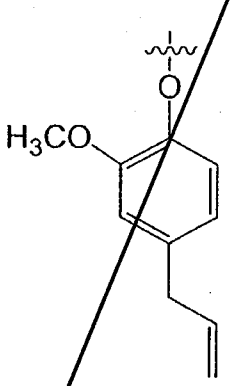
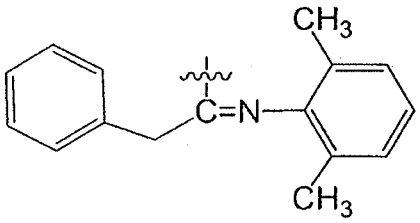


; or



15. An olefin polymerization process comprising contacting the catalyst composition of any of claims 1 -14 with an olefin monomer and optionally an olefin comonomer under polymerization conditions to produce a polymer or copolymer.

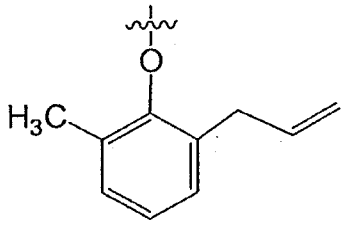
16. The process of claim 15, wherein the catalyst composition and the olefin monomer are contacted in a gas phase reactor, a loop slurry reactor, or a stirred tank reactor.

17. The process of claim 15, wherein the olefin monomer comprises ethylene, propylene, or styrene.

18. The process of claim 15, wherein the olefin comonomer is 1-butene, 2-butene, 3-methyl-1-butene, isobutylene, 1-pentene, 2-pentene, 3-methyl-1-pentene, 4-methyl-1-pentene, 1-hexene, 2-hexene, 3-ethyl-1-hexene, 1-heptene, 2-heptene, 3-heptene, 1-octene, or styrene.

19. A compound having the formula:

Indenyl(X^4)Zr(CH_2Phenyl)$_2$; wherein X^4 is



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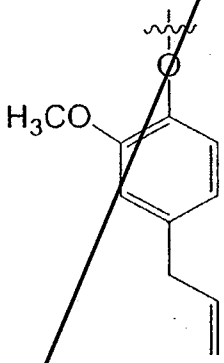
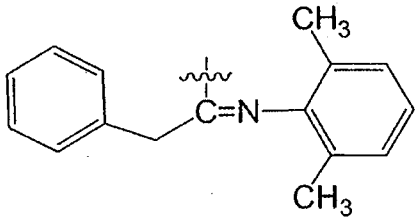


; or



We claim:

1. A catalyst composition comprising a contact product of at least one hybrid metallocene compound and at least one activator,

wherein the at least one hybrid metallocene compound has the formula:

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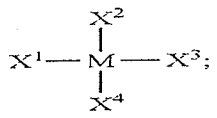


wherein:

M is Zr, Hf, or Ti;

X^1 and X^2 independently are a halide or a substituted or unsubstituted aliphatic, aromatic, or cyclic group, or a combination thereof;

X^3 is a substituted or unsubstituted cyclopentadienyl, indenyl, or fluorenyl group, any substituents on X^3 independently are a hydrogen atom or a substituted or unsubstituted aliphatic, aromatic, or cyclic group, or a combination thereof;

X^4 is —O—R^A, —NH—R^A, —PH—R^A, —S—R^A, or —CR^B=NR^C,

wherein:

R^A is an aryl group substituted with at least one alkenyl substituent, any substituents on R^A other than the at least one alkenyl substituent independently are a hydrogen atom or a substituted or unsubstituted alkyl, alkenyl, or alkoxy group; and

R^B and R^C independently are a hydrogen atom or a substituted or unsubstituted aliphatic, aromatic, or cyclic group, or a combination thereof.

2. The catalyst composition of claim 1, wherein X^1 and X^2 independently are a methyl group, a phenyl group, a benzyl group, or a halide.

3. The catalyst composition of claim 1, wherein each substituent on X^3 independently is a hydrogen atom, a methyl group, an ethyl group, a propyl group, an n-butyl group, a t-butyl group, or a hexyl group.

4. The catalyst composition of claim 1, wherein the at least one alkenyl substituent on R^A is an ethenyl, a propenyl, or a butenyl.

5. The catalyst composition of claim 1, wherein each substituent on R^A other than the at least one alkenyl substituent independently is a hydrogen atom, a methyl group, an ethyl group, a propyl group, an n-butyl group, a t-butyl group, a methoxy group, an ethoxy group, a propoxy group, or a butoxy group.

6. The catalyst composition of claim 1, wherein X^4 is —O—R^A.

7. The catalyst composition of claim 1, wherein R^B and R^C independently are a hydrogen atom, a methyl group, an ethyl group, a propyl group, an n-butyl group, a t-butyl group, a phenyl group, a benzyl group, a tolyl group, or a xylyl group.

8. The catalyst composition of claim 1, wherein the at least one activator is at least one activator-support comprising a solid oxide treated with an electron-withdrawing anion, wherein:

the solid oxide is silica, alumina, silica-alumina, aluminum phosphate, heteropolytungstates, titania, zirconia, magnesia, boria, zinc oxide, any mixed oxides thereof, or any mixture thereof; and

the electron-withdrawing anion is fluoride, chloride, bromide, phosphate, triflate, bisulfate, sulfate, or any combination thereof.

9. The catalyst composition of claim 8, wherein the at least one activator-support further comprises a metal or metal ion, and wherein the metal or metal ion is zinc, nickel, vanadium, silver, copper, gallium, tin, tungsten, molybdenum, or any combination thereof.

10. The catalyst composition of claim 1, wherein the at least one activator is at least one activator-support, and wherein the at least one activator-support is fluorided alumina, chlorided alumina, bromided alumina, sulfated alumina, fluorided silica-alumina, chlorided silica-alumina, bromided silica-alumina, sulfated silica-alumina, fluorided silica-zirconia, chlorided silica-zirconia, bromided silica-zirconia, sulfated silica-zirconia, or any combination thereof.

11. The catalyst composition of claim 1, wherein the at least one activator is at least one activator-support comprising a clay mineral, a pillared clay, an exfoliated clay, an exfoliated clay gelled into another oxide matrix, a layered silicate mineral, a non-layered silicate mineral, a layered aluminosilicate mineral, a non-layered aluminosilicate mineral, or any combination thereof.

12. The catalyst composition of claim 1, further comprising at least one organoaluminum compound having the formula:

$$Al(X^5)_m(X^6)_{3-m};$$

wherein:

X^5 is a hydrocarbyl;

X^6 is an alkoxide or an aryloxide, a halide, or a hydride; and

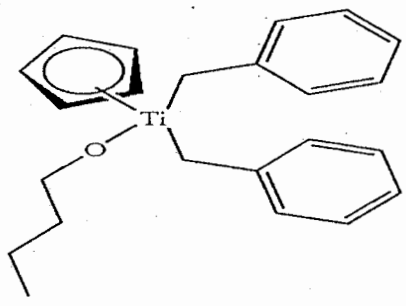
m is from 1 to 3, inclusive.

13. The catalyst composition of claim 12, wherein the at least one organoaluminum compound is trimethylaluminum, triethylaluminum, tri-n-propylaluminum, diethylaluminum ethoxide, tri-n-butylaluminum, diisobutylaluminum hydride, triisobutylaluminum, diethylaluminum chloride, or any combination thereof.

14. The catalyst composition of claim 1, wherein the at least one activator is at least one aluminoxane compound, at least one organoboron or organoborate compound, at least one ionizing ionic compound, or any combination thereof.

15. A catalyst composition comprising a contact product of at least one hybrid metallocene compound and at least one activator,

wherein the at least one hybrid metallocene compound is:



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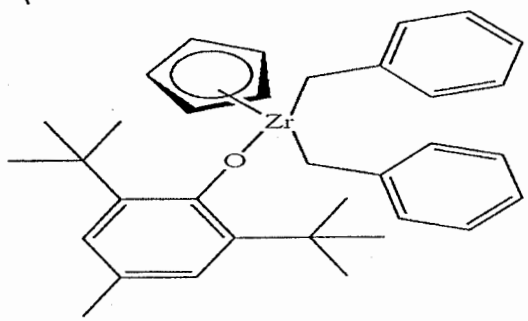

; or

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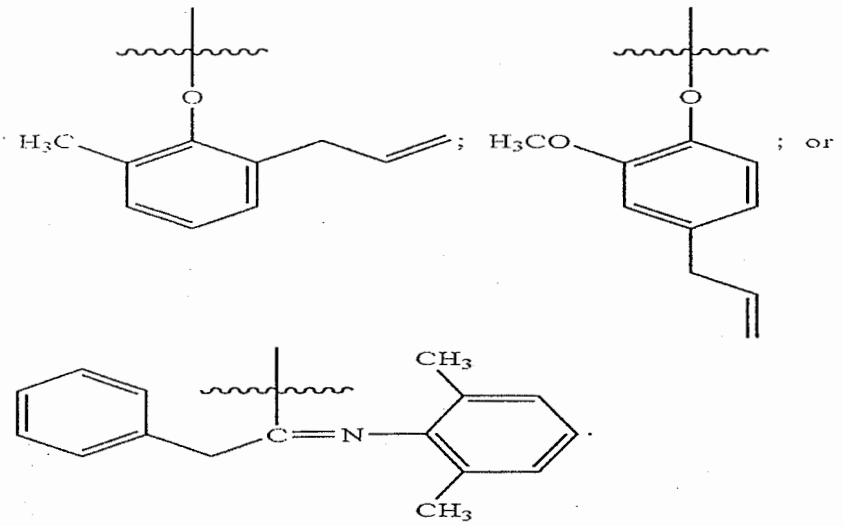
Indenyl(X^4)Zr(CH_2Phenyl)$_2$; wherein X^4 is



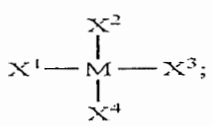
16. The catalyst composition of claim 15, wherein the at least one activator is at least one activator-support, at least one aluminoxane compound, at least one organoboron or organoborate compound, at least one ionizing ionic compound, or any combination thereof, wherein:

the at least one activator-support is fluorided alumina, chlorided alumina, bromided alumina, sulfated alumina, fluorided silica-alumina, chlorided silica-alumina, bromided silica-alumina, sulfated silica-alumina, fluorided silica-zirconia, chlorided silica-zirconia, bromided silica-zirconia, sulfated silica-zirconia, or any combination thereof.

17. The catalyst composition of claim 15, wherein the catalyst composition further comprises at least one organoaluminum compound selected from trimethylaluminum, triethylaluminum, tri-n-propylaluminum, diethylaluminum ethoxide, tri-n-butylaluminum, diisobutylaluminum hydride, triisobutylaluminum, and diethylaluminum chloride, or any combination thereof.

18. A process for polymerizing olefins in the presence of a catalyst composition, comprising contacting the catalyst composition with at least one olefin monomer and optionally at least one olefin comonomer under polymerization conditions to produce a polymer or copolymer, wherein the catalyst composition comprises a contact product of at least one hybrid metallocene compound and at least one activator,

wherein the at least one hybrid metallocene compound has the formula:



(I)

wherein:

M is Zr, Hf, or Ti;

X^1 and X^2 independently are a halide or a substituted or unsubstituted aliphatic, aromatic, or cyclic group, or a combination thereof;

X^3 is a substituted or unsubstituted cyclopentadienyl, indenyl, or fluorenyl group, any substituents on X^3 independently are a hydrogen atom or a substituted or unsubstituted aliphatic, aromatic, or cyclic group, or a combination thereof;

X^4 is —O—R^A, —NH—R^A, —PH—R^A, —S—R^A, or —CR^B=NR^C,

wherein:

R^A is an aryl group substituted with at least one alkenyl substituent, any substituents on R^A other than the at least one alkenyl substituent independently are a hydrogen atom or a substituted or unsubstituted alkyl, alkenyl, or alkoxy group; and

R^B and R^C independently are a hydrogen atom or a substituted or unsubstituted aliphatic, aromatic, or cyclic group, or a combination thereof.

19. The process of claim **18**, wherein the at least one activator is at least one activator-support, at least one aluminoxane compound, at least one organoboron or organoborate compound, at least one ionizing ionic compound, or any combination thereof, wherein:

the at least one activator-support is fluorided alumina, chlorided alumina, bromided alumina, sulfated alumina, fluorided silica-alumina, chlorided silica-alumina, bromided silica-alumina, sulfated silica-alumina, fluorided silica-zirconia, chlorided silica-zirconia, bromided silica-zirconia, sulfated silica-zirconia, or any combination thereof.

20. The process of claim **18**, wherein the catalyst composition further comprises at least one organoaluminum compound selected from trimethylaluminum, triethylaluminum, tri-n-propylaluminum, diethylaluminum ethoxide, tri-n-butylaluminum, diisobutylaluminum hydride, triisobutylaluminum, and diethylaluminum chloride, or any combination thereof.

21. The process of claim **18**, wherein the catalyst composition and the at least one olefin monomer and the optional at least one olefin comonomer are contacted in a gas phase reactor, a loop reactor, or a stirred tank reactor.

22. The process of claim **18**, wherein at least one olefin monomer comprises ethylene, propylene, or styrene.

23. The process of claim **22**, wherein the at least one olefin comonomer is 1-butene, 2-butene, 3-methyl-1-butene, isobutylene, 1-pentene, 2-pentene, 3-methyl-1-pentene, 4-methyl-1-pentene, 1-hexene, 2-hexene, 3-ethyl-1-hexene, 1-heptene, 2-heptene, 3-heptene, 1-octene, or styrene.

24. A compound having the formula:

Indenyl(X^4)Zr(CH_2Phenyl)$_2$; wherein X^4 is

